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Studies on chromosomal translocation in *Haworthia*[1]

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Abstract : The normal karyotype of most species of the tribe Aloineae comprises 8 long and 6 short chromosomes. It was observed that in a diploid plant of *Haworthia attenuata* var. *britteniana* f. V. Poelln., there occured a simple translocation between the L_4 and L_2 chromosomes. The detailed description is $K=2n=8L+6S=2L_1+1L_2+1L_T+2L_3+1L_4+1L_D+2S_1+2S_2+2S_3$. Among the 337 cells examined at meiosis, the quadrivalent chromosomes involving translocation in the form of $(1L_2+1L_T)$ and $(1L_4+1L_D)$ was observed in 285 cells, pairings of either $(1L_2+1L_T)$ or $(1L_4+1L_D)$ to form bivalents were found in 48 cells, and other chromosome pairings were observed in 4 cells. Pollen grains appeared to be 50% viable.

The normal karyotype of most species of the tribe Aloineae comprises 8 long and 6 short chromosomes [10,11,16]. Hexaploid and octoploid plants of *Haworthia* have been detected with chromosomal aberrations : they bear a simple translocation accompanied by other complex structural abnormalities, and deletion, respectively. The somatic chromosome studies of these two plants have been published [4,5,6]. Recently, a diploid plant of *Haworthia* was found to bear simple translocation. Although some plants of Aloineae had previously been studied [1,2,13,14], this plant was the first reported with karyotype analysis. In order to detect the chromosomal behavior, detailed cytogenetical studies have been made on this abnormal plant, a diploid plant (2x=14) of *H. attenuata* var. *britteniana* f. (68-083-222).

Material and Method

Plants of *H. attenuate* var. *britteniana* f. was obtained from the Izu Natural History Park, Shizoka, Japan. It was originally from South Africa where the genera are indigenous. Root tips were collected for study of somatic chromosome behavior. The squash technique is as follows : (1) as pretreatment, root tips were treated for 2 hours in 0.002 M 8-oxyquinoline at 18°C-20°C ; (2) fixed in Carnoy's solution (3 : 1) for 24 hours ; (3)

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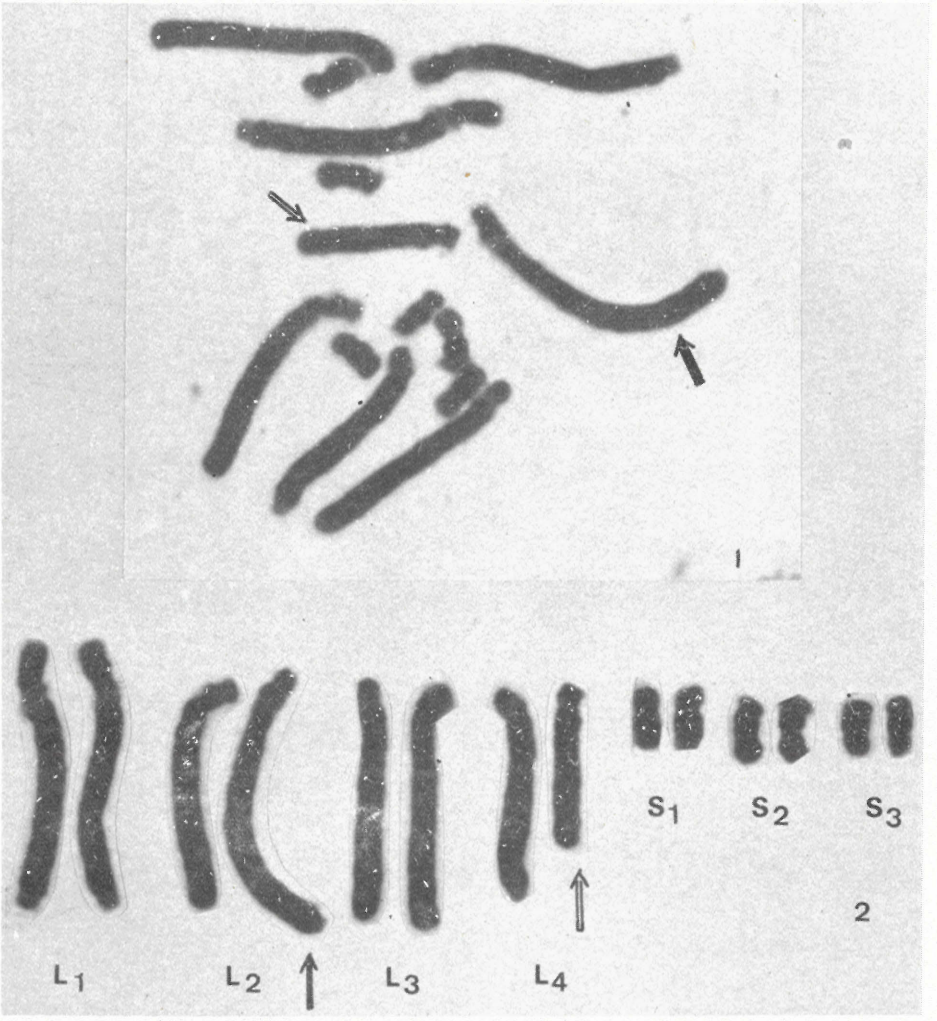
hydrolyzed in 1N-HCl for 6 minutes at 60°C ; (4) stained in feülgen solution ; (5) finally they were squashed in aceto-carmine. Pollen fertility and sterility were detected after staining the pollen grains in acetocarmine-glycerin jelly (1 : 1).

Results aud Discussion

H. attenuata var. *britteniana* f. (68-083-222)

Leafy stem, rosette ; leaves green, becoming reddish with age, acuminate, the tip dries before the leaf becomes fully mature, 40-50mm. long, 9-12mm. wide at the base, back with white tubercles arranged in regular transverse bands, keeled from the middle to the



Figs. 1-2. *H. attenuata* var. *britteniana* f. (68-083-222), 2n=8L+6S=14.

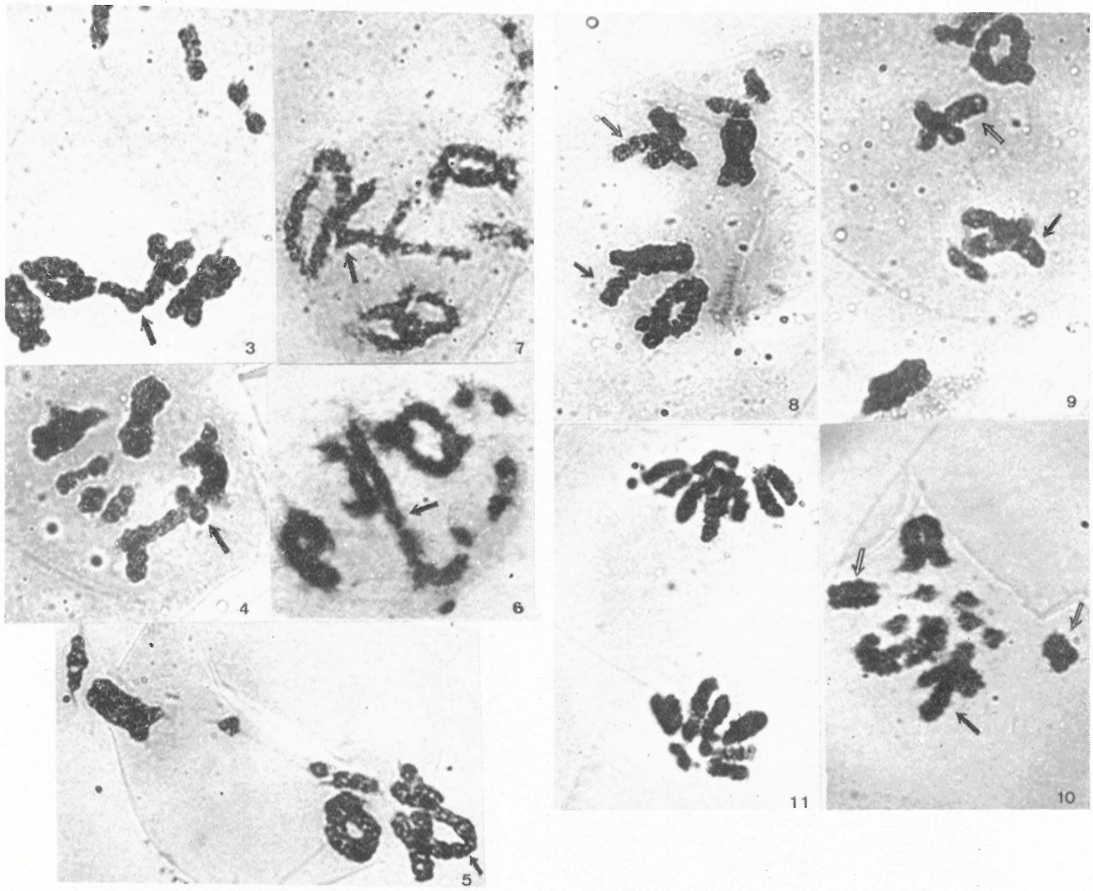
Fig. 1. Somatic metaphase with 2n=8L+6 S=14 chromosomes. The arrows indicate the long translocation chromosomes. **Fig. 2.** Karyotype. The arrows indicate the long translocation chromosomes.

tip, margins with white teeth [8].

Peduncle branched, to about 45cm. long ; pedicels 4mm. long ; bracts 3-4mm. long ; perianth white-greenish, with green-brownish lines, 11-12mm. long [8].

According to John [9], "*Haworthia attenuata* var. *britteniana* Von Poelln. is variable, but is characterized by a thick encrustation of white tubercles. On the back of the leaf they tend to come in two size, the larger loosely arranged in band across the leaf, the smaller in random clusters between them ; the upper surface is covered with small tubercles giving the appearance of frosting."

The plant is a diploid and bears a simple translocation ($K=2n=8L+6S=2L_1+1L'_2+$



Figs. 3-11. *H. attenuata* var. *britteniana* f. (68-083-222).

Figs. 3-5. Meiotic metaphase I showing $1\text{Ⅳ}\,[(1L_2+1L_T)+(1L_4+1L_D)]+2\text{Ⅱ}(L)+3\text{Ⅱ}(S)$. The arrows indicate the long translocation chromosomes. **Figs. 6-7.** Late diakinesis. **Figs. 8-9.** Meiotic metaphase I showing $2\text{Ⅱ}(L)+2\text{Ⅱ}(L)[(1L_2+1L_T),\ (1L_4+1L_D)]+3\text{Ⅱ}(S)$. The arrows indicate the long translocation chromosomes. **Fig. 10.** Meiotic metaphase I showing $3\text{Ⅱ}(L)+2\text{Ⅰ}(L)\ (1L_4,\ 1L_D)+3\text{Ⅱ}(S)$. The arrows indicate the long translocation chromosomes. **Fig. 11.** Anaphase I showing a normal separation.

$1L'_T+2L_3+1L_4+1L_D+2S_1+2S_2+2S_3$). Figures 1 and 2 reveal that one of the normal long chromosomes is of the L_4 type with a satellite at the end of the long arm. The five other normal long chromosomes are $2L_1$, $1L_2$ and $2L_3$. The interesting abnormal long chromosome is one L_4chromosome which has a long arm about one-third shorter than that of the normal L_4chromosome. One L_2 chromosome is noticeably longer than the other and has a satellite at the end of the long arm. Measurements of the length of the long arms of these two chromosomes were made and were compared with those of the translocated chromosomes. They are given in Fig. 12.

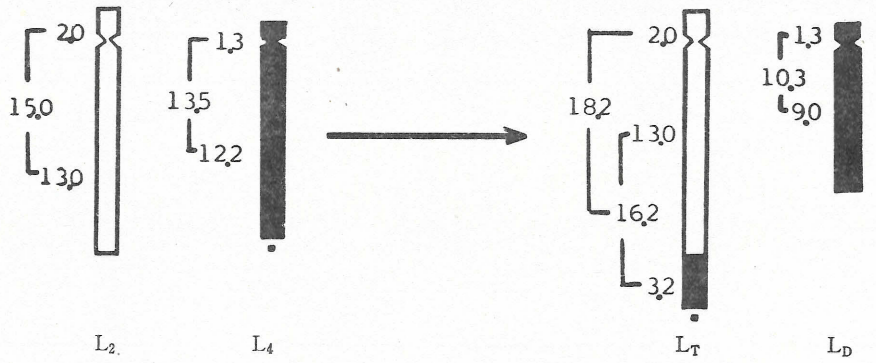


Fig. 12. A possible mechanism by which the translocated chromosomes could have arisen in *H. attenuata* var. *britteniana* f.

Apparently this interchange involves an L_4 and an L_2 chromosomes. It can be seen that a segment about one-third (3.2μ) the length of the long arm breaks at the end of one of the L_4 chromosomes and is translocated to the end of the long arm of one of

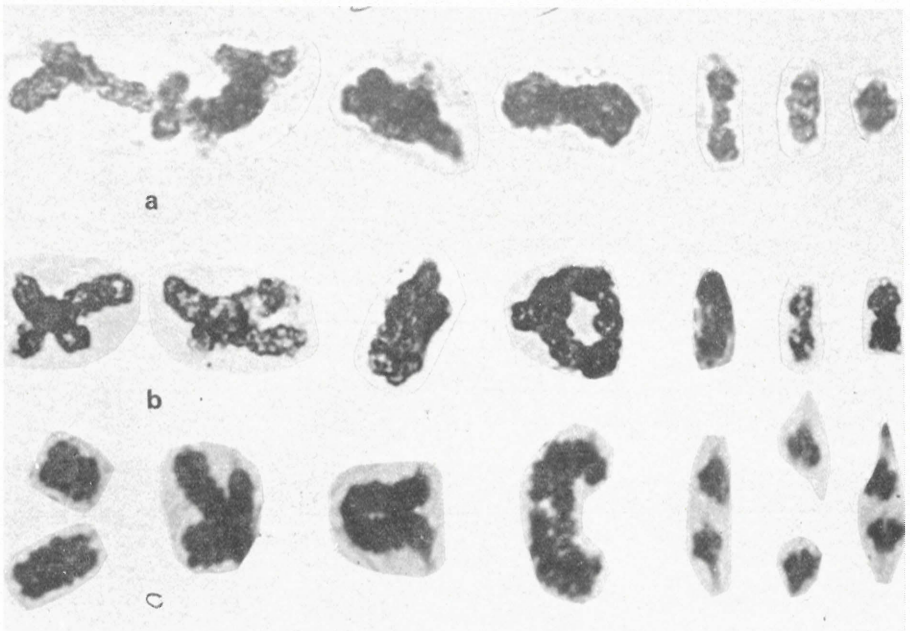


Fig. 13. Chromosome pairing at meiotic metaphase I in translocated *H. attenuata* var. *britteniana* f.

the L_2 chromosomes (Fig. 12). There is no break occurred at centromere as reported by Riley and his co-workers [13,14]. Although many diploid plants of the Aloineae had previously been studied [1,2,13,14,16], this was the first plant reported with this aberration.

Meiotic behavior is illustrated in Table 1. In the *Haworthia* plants studied so far the pachytene stage could not be analyzed [6,15]. Therefore the types of translocation configuration have to be identified by studying the late diakinesis (Figs. 6 and 7) and metaphase I stage of meiosis. Figure 13 shows the types of translocation association.

Table 1. Pairing associations at metaphase I of *H. attenuata* var. *britteniana* f. with translocations

Metaphase I configurations	No. of PMCs observed	
1Ⅳ(L) + 2Ⅱ(L) + 3Ⅱ (S)·····	285	(Figs. 3 - 5)
4Ⅱ (L)+ 3Ⅱ(S)·····	48	(Figs. 8 & 9)
2Ⅱ (L) +2Ⅰ (L) + 3Ⅱ (S)·····	4	(Fig. 10)
Total	337	

The quadrivalent configurations involving ($1L_2+1L_T$) and ($1L_4+1L_D$) (Fig. 13-a) were seen in 285 cells; the pairings of either ($1L_2+1L_T$) or ($1L_4+1L_D$) to form bivalents were found in 48 cells (Fig. 13-b); and in 4 cells the ($1L_4$, $1L_D$) chromosomes were unpaired to form two univalents and the ($1L_2+1L_T$) chromosomes were paired to form bivalent configurations (Fig. 13-c).

In 337 cells, the long chromosomes were arranged in 285 quadrivalents, 774 bivalents and 8 univalents. The short chromosomes were arranged in 1,053 bivalents.

At anaphase of the microspore division, 18.2% of the cells had irregularities consisting of chromatin bridges, bridges and fragments. Of the 530 "tetrads" studied, there were one one-cell "tetrads", five three-cell "tetrads", two five-cell "tetrads", and 522 four-cell "tetrads".

Table 2. Characteristics of microspore anaphase and pollen of the diploid simple translocation

Stages	Characteristics	No. observed	Percentage (%)
Microspore anaphase	Chromatin bridges, bridges and fragments	10	18.2
	Regular	45	81.8
	Total	55	
Pollen	Shriveled, unstained, and apparently sterile	367	49.8
	Stained and apparently fertile	370	50.2
	Total	737	

Acetocarmine squashes of mature pollen grains showed that 50.2% were stained and appeared to be normal, and the remaining 49.8% were shriveled, unstained and apparently sterile. Pollens appeared to be 50% viable according to Brink [3] in his report on chromosome translocations in Maize.

Translocation in *H. attenuata* var. *britteniana* f. is a simple translocation. In *Haworthia*, such a translocation has been detected so far in only this plant reported here which is a translocation heterozygote. In maize, alternate and adjacent types occur with equal frequency and, as the latter produce inviable gamete, pollens of the plant heterozygous with such a translocation are about 50% sterile [3]. The plant reported in this paper strongly resembles the maize plant. Interchange occurs between chromosomes L_2 and L_4.

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Haworthia 屬植物染色體轉座現象之研究[1]

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中 文 摘 要

百合科 Aloineae 族植物之染色體爲典型之 "Bimodal" 核型，即有 8 個大型染色體與 6 個小型染色體 (8L+6S). *Haworthia* 屬中之 *H. attenuata* var. *britteniana* f. V. Poelln. 爲 2 倍體，核型分析結果，在 L_2 與 L_4 染色體上產生單轉座現象，其核型爲 $K=2n=8L+6S=2L_1+1L_2+1L_T+2L_3+1L_4+1L_D+2S_1+2S_2+2S_3$，減數分裂顯示，在 337個細胞中，兩組相同染色體各相配對且其單向轉座部份之染色體對合成Ⅳ價者，有 285 個細胞；相同染色體配對成Ⅱ價，而轉座部分不相對合者，有48個細胞；其他者有 4 個細胞，花粉稔性僅 50%。

1. 臺灣省農業試驗 研究報告 第 1014 號。
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